INFOCOMP - the Compositae Types digital imaging project in Munich

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Summary:
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INFOCOMP is a project that uses modern archiving techniques for traditional botanical resources to make them globally available and conserve them for future generations. It involves the digital imaging of Compositae nomenclatural types. An estimated 3,000 types of this plant family are held in the Munich public herbarium (Botanische Staatssammlung München and Systematische Botanik der Ludwig-Maximilians-Universität München). On average, five digital images of each type sheet are taken showing labels, habit and taxonomically relevant details. The type material is scientifically evaluated consulting the original species descriptions as well as other resources. The complete database of ca 15,000 images and the linked bibliographic information should be fully available over the Internet by the end of 2002. Brief analysis of the type database indicates that Africa, Central and South America are the main geographical foci for the Compositae type collections. The proportional representation of various type categories as well as significant collectors and authors are discussed.

Zusammenfassung:
INFOCOMP nutzt moderne Archivierungstechniken, um traditionelle botanische Datenbestände weltweit zugänglich zu machen und für zukünftige Generationen zu erhalten. Dieses Projekt befaßt sich speziell mit der digitalen Erfassung der nomenklatorischen Typen der Compositae. Das Münchener Staatsherbar (Botanische Staatssammlung München und Systematische Botanik der Ludwig-Maximilians-Universität München) beherbergt schätzungsweise 3.000 Typen aus dieser Pflanzenfamilie. Durchschnittlich fünf hochauflösende Digitalphotos zeigen Herbaretiketten, Habitus und relevante Details jedes Typusbeleges. Vor Aufnahme in die Datenbank wird der Typusstatus sorgfältig überprüft. Hierfür werden sowohl die Originalbeschreibungen als auch modernere taxonomische Literatur eingesehen. Der vollständige Datensatz von ca. 15.000 Bildern, jeweils in standardisierter Form mit den bibliographischen Informationen verknüpft, soll bis Ende des Jahres 2002 sukzessive im Internet zugänglich gemacht werden. Die bisher in der Datenbank enthaltenen Angaben weisen auf Afrika, sowie Zentral- und Südamerika als geographische Schwerpunkte in der Kompositensammlung des Münchener Staatsherbars. Die prozentuale Verteilung der Herbarbelege auf die einzelnen Typuskategorien sowie besonders häufig vertretene Sammler und Autoren werden vorgestellt.

Introduction

European botanical collections are not only repositories for native plants but also for significant portions of tropical and subtropical material. This is largely a result of imperial exploration in the 18th and 19th centuries. Articles 12 (research and training contributing to biodiversity conservation) and 17 (facilitate the exchange of relevant information) of the 1992 Biodiversity Convention (see http://www.biodiv.org/) obligate developed countries curating these valuable plant resources to maintain them and also to make them widely available (BARTHLOTT 2001). Within the framework of the German initiative "Biodiversity and Global Change" (BIOLOG) research program "Biodiversity Informatics" forms a significant component. Biodiversity Informatics encompasses the rationale of an effective electronic information infrastructure, which can be used to access past research and data resources that provide the necessary background for knowledge from new results (BERENDSOHN 2001). In practice, this means the documentation and data mining of the enormous information sources represented by biological collections in Germany, including botanical collections. INFO-COMP is part of the co-operative project INFOBOT (Development and Testing of Information Systems for the Processing of Different Aspects of Botanical Collections) within the BIOLOG program.

The Compositae (Asteraceae or Sunflower family) form the largest flowering plant family in the world, with an estimated 25,000 species (HEYWOOD 1993). They are found in all places colonised by higher plants on all continents. They often form significant parts of the most diverse ecosystems (HEYWOOD et al. 1977). The overall ecological and economical importance of the Compositae means that any knowledge gleaned about it is indispensable, not only for biodiversity analysis, but also in realm of environmental evaluation and research. In these, and related topics, familiarity with, and accessibility of, the nomenclatural types is a prerequisite. Nomenclatural types are the reference sheets of pressed plants laid down in herbaria. These are directly and permanently connected to their plant names and allow species to be unambiguously identified (INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE 2000), underpining even the most modern research techniques.

Founded in 1813 by the Bavarian king Maximilian I Joseph as "Herbarium Regium Monacense" (see HERTEL & SCHREIBER 1988), the Munich public herbarium - Botanische Staatssammlung München (herbarium acronym M; after HOLMGREN et al. 1990) - is one of the oldest and most significant in Germany. It holds approximately 2.5 million collections of which an estimated 30,000 are types. Within the phanerogam herbarium there are around 270,000 Compositae specimens (SCHUHWERK, pers. comm.) of which ca 3,000 are types. Material from the Systematische Botanik der Ludwig-Maximilians-Universität München (MSB) was incorporated into these collections in 1991 (PODLECH, pers. comm.). Together with the herbaria of the Friedrich-Schiller-Universität Jena (JE) (ca 3,000,000 specimens), the Botanisches Museum Berlin-Dahlem (B) (ca 2,500,000 specimens), and the Institut für Allgemeine Botanik Hamburg (HBG) (ca 1,200,000 specimens) M (including MSB) ranks among the four largest herbaria in Germany (HOLMGREN et al. 1990).

Imaging of herbarium specimens, especially nomenclatural types, has long been acknowledged as a useful safety net for botanical collections. The images (e.g., photos, photocopies) are used mainly as supplementary, or alternative, to loans of fragile, rare or important material. A prime example is the extensive photographic collection from MacBride in the 1920's. It is now being scanned and is partially available over the web through the Field Museum in Chicago (F)[1]. The presentation of type collections and material of historical interest in a digitised format on the Web is becoming increasingly popular. Several pioneer projects started around the turn of the 21st century - the Swedish Museum of Natural History

[1] for type database internet addresses see references

(S) digitising the Linnean types held there, the Leiden Nationaal Herbarium (L) recording the types of all vascular plants held in Dutch herbaria, for example. The herbarium sheets were digitised directly using flatbed scanners. Some projects have chosen to take photographic slides of the herbarium sheets, which have then been digitised by scanning the slides. These include the vascular plant type database of the National Herbarium of New South Wales in Australia (UNSW), and the initial phases of a similar project at the Missouri Botanical Gardens (MO). The latter, however, changed from scanning slides to using a digital camera. The New York Botanical Gardens (NYBG) have also used a digital camera system to archive their phanerogam type collections. The Botanisches Museum Berlin-Dahlem (B) has plans to record its type collections using a digital camera. INFOCOMP represents the first specifically funded project of this kind in Germany.

Project Structure & Organisation

The INFOCOMP project started in April 2000 and is scheduled to finish in April 2003. It is supported by three graduate scientists and, from time to time, a Database/Network administrator, adding up to a total of 4.5 man-years.

INFOCOMP has two parallel areas of operation: the photographic and computer work, and the library-based research. Two people are responsible for the imaging and databasing, and one person for the evaluation and collation of bibliographic information.

Data Collection

Digital Imaging & Processing:
The photography is carried out using a Nikon D1 digital camera and flash (+ diffuser). The camera apparatus has the great advantage of being highly mobile - very useful when working in herbaria. It also allows flexibility when taking the images, especially when placing measuring rules in various positions on the type sheets to achieve the most effective presentation of relevant characters (both large scale and macro pictures). Photos are taken with a resolution of 2,000 x 1,312 pixels using JPEG file format (a 24-bit compression format well suited to screen and print presentation). JPEG is supported by all major computer platforms and by Internet web browsers.

The pictures are transferred to computers where they are checked over and standardised using Adobe® Photoshop® 5.5. The software image processing procedure is kept to a minimum and only involves standard commands (e.g., rotation, brightness, contrast) for aesthetic presentation. This is done to enhance the true image and in no way adds "non-existent" features.

On average, five photos per type sheet are taken: the original label(s), the entire sheet, relevant habit detail, and macro images of taxonomically important structures - most often the capitulum(a). All plant pictures include a measuring scale. Standardisation and quality control is completed before they are entered in the operational database. The type specimen of *Arctotis merxmuelleri* Friedrich, shown in Plates 1a and 1b, demonstrates a sample of the 'typical' digitised images available from the INFOCOMP database.

Type Evaluation & Bibliographic Research:
Species names are primarily checked using the International Plant Names Index (IPNI, provided by THE PLANT NAMES PROJECT 1999), although a more intensive literature search is often required. The author abbreviations as well as the full names of authors and collectors are usually taken from BRUMMIT & POWELL (1992).

Plate 1a: Type sheet of *Arctotis merxmuelleri* Friedrich.

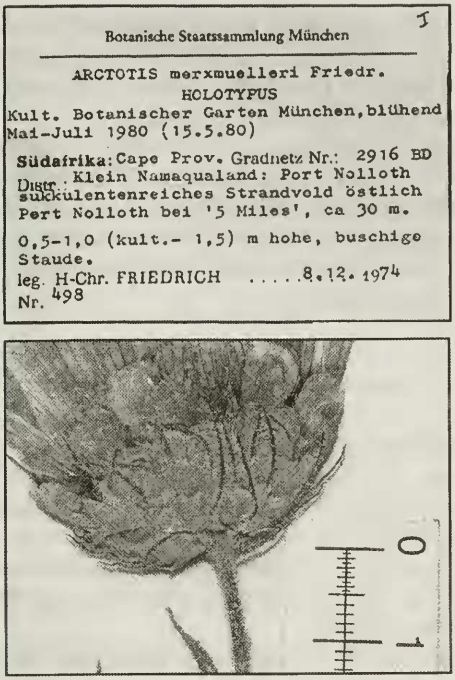
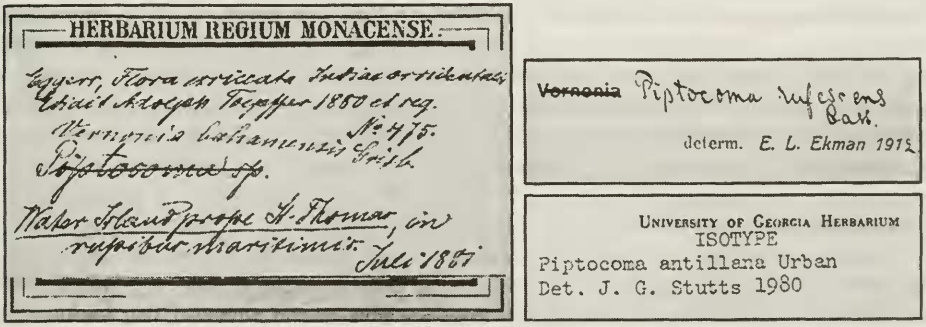


Plate 1b: Label and detail images of type sheet of *Arctotis merxmuelleri* Friedrich.



Basionym	*Piptocoma antillana* Urb.
Tribe	Vernonieae
Author	Urban, I.
Protologue reference	Arkiv för Botanik utgivet av K. Svenska Vetenskapsakademien 23 A(11): 50-51. 1931.
Type status	Isotypus
Collector	Eggers, H.F.A. von
Collection number	475
Herbarium/Collection	Eggers, Flora indiae occidentalis exsiccata (ed. A. Toepffer)
Continent	North America
Country	U.S.A. (Lesser Antilles, Virgin Islands)
Region	" ... Water Island prope St. Thomas ... in rupibus maritimis ... " (op. cit.)
Collection year	1881
Comments	
Image category	Label 1/Label 2/ Label 3

Plate 2: Labels on type collection of *Piptocoma antillana* Urb. and the additional text information gathered from the literature.

In order to verify the protologue citations the references B-P-H (LAWRENCE et al. 1968; BRIDSON 1991) and TL2 (STAFLEU & COWAN 1976–1988; STAFLEU & MENNEGA 1992–2000) are consulted. The validity of the material and its status as a type is corroborated in the literature, not only back to the original protologue, but also in the more modern revisions where they exist. Types are listed in the database according to their basionyms.

Where the type status is clear according to the literature, but the category cannot be established, the database field is entered only as "Typus". Interestingly, of the specimens already marked in the Munich herbarium as type material, only 1–2% have been put aside. These are usually later identified as representatives of *nomina nuda* (names without a valid publication), or the collection numbers, collectors or collection sites of the material held in Munich are different from those published in the protologue.

Special emphasis is placed upon the correct and accurate protologue citation. It is always given in full, without abbreviations that can be misquoted. The page numbers include the complete type protologue and any accompanying illustrations and figures.
E.g.,

Acta Botanica Neerlandica 9(3): 302-303 (316 fig.). 1960.

Complementary information not available or legible on herbarium sheet (e.g., author, collector, continent and, most often, locality) is also verified from the literature.

'THE TIMES' ATLAS OF THE WORLD (1985) is the reference for the boundaries of the continents and countries in which the collection sites are located nowadays. The tribal placement of the genera is cited according to BREMER (1994).

Plate 2 shows the labels from a type collection of *Piptocoma antillana* Urb. and the extracted information which will later be linked with the images. When possible, the following areas are covered: basionym, tribal placement, author, protologue citation (in full), type status (e.g., Holotypus), collector, collection number and year, herbarium/collection (e.g., ex herb. Schreber), continent, country, region, comments, and image category (e.g., label, sheet, detail). The information is only included where it is clearly recognisable or can be inferred using taxonomic skills.

Data Organisation

For the internal organisation of the project the two database software programs "iView MediaPro" and "Filemaker Pro" are being used for data administration. The former is for the organisation of the image and text data, while retaining flexibility for other software options. The latter is used to capture the data and provides an integrated web interface allowing direct access to the database via the World Wide Web.

Technical Aspects

The Compositae type collections in Munich contain representatives from the most diverse genera. These vary from the heavy-headed, spiny members of the thistle-related genus *Cousinia* to the fragile, pubescent species of *Gnaphalium*, from the glossy, papery flowering heads of *Helichrysum* specimens to the often densely glandular capitula of *Hieracium* taxa. In order to photograph such variation in a consistent fashion a diversity of techniques is required. The difficulty of imaging a very thick herbarium specimen can be demonstrated using *Cousinia gigantoptera* Rech.f. & Podlech as an example. In this case the dimensions of the material are too large to include all details in the available depth of field. The shiny involucral bracts of *Helichrysum difficile* Hilliard are highly reflective. Consequently photos

have to be taken without using any artificial light source. The imaging of special features of *Hieracium* taxa turned out to be quite a challenge, details of which are to be published separately (DAVIES et al., in progress).

Results

INFOCOMP was presented at the Bonn BIOLOG conference both in poster format and as a status report (GRAU et al. 2001). The project was taken to the 6th *Hieracium* workshop in Hirschegg (Austria) as a poster and computer demonstration (DAVIES et al. 2002). The results presented here are mostly to give the Compositae taxonomists a general idea of the potential database content. Types from all seventeen of the Compositae tribes have been recorded. As of June 2002 360 genera and 2,500 types have been photographed, forming a database of over 10,500 images.

Diagram 1 illustrates the number of genera containing types held in Munich as a percentage of the total number of genera in the tribe to which they belong (after BREMER 1994). The shaded column area represents the percentage of those taxa for which the digital imaging has already been completed. The blank column area shows the percentage of taxa that remain to be photographed. Material from the following tribes still has to be imaged: Anthemideae, Astereae, Eupatorieae, Senecioneae, Cardueae, Lactuceae, and Mutisieae. These type specimens are not included in the following statistical surveys.

Type categories:
From a sample size of 1,600 scientifically evaluated types 42% are isotypes, 25% "Typus", 16% holotypes, and 7% syntypes. The remaining material is defined more specifically. The percentile distribution of the type categories is presented in Diagram 2.

Geographical emphasis:
The continental distribution of Munich's Compositae types, taken from a sample of 1,600 types, is shown in Diagram 3. The sample is dominated by African types. These have been collected mainly in southern Africa (Republic of South Africa, Namibia, Zambia, and Angola) and Ethiopia. The Americas are also well represented. The North American types are dominated by material from Mexico and from the Pacific (the Hawaiian Islands) and Caribbean islands. South American types originate mainly from Brazil, Bolivia, and Chile. Main focal points of the collectors in Asia have been Afghanistan, the Himalaya region, and Kazakhstan. Not included in these numbers are the distribution data of the genus *Hieracium* s.l., which is concentrated in Europe (DAVIES et al. 2002).

Authors, Collectors & Collections:
During the course of the taxonomic literature research several figures of botanical interest, often historical, repeatedly appeared. As many larger herbaria, Munich has private herbaria – either donated or purchased – incorporated into the general collection. Consequently, contributions from famous plant collectors and authors of plant names as well as those of less well known botanists can be found.

The Munich herbarium is especially famous for the historical Carl Friedrich Philipp von Martius (1794-1868) material, gathered on commission for the Bavarian king between 1817 and 1820 in the Brazilian jungle (HERTEL & SCHREIBER 1988). This rich collection contains many holotypes, not only in the Compositae.

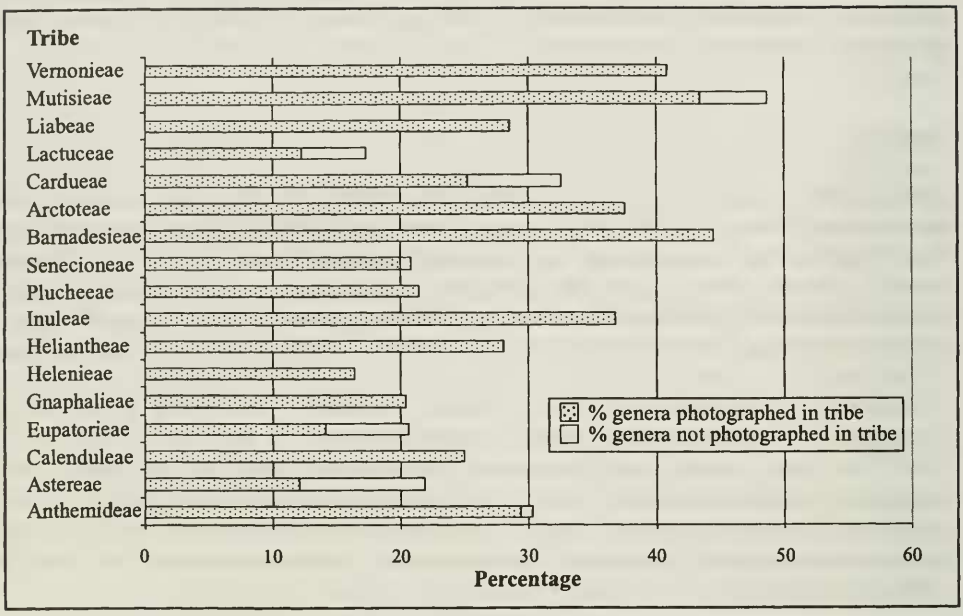


Diagram 1: Number of genera containing types as a percentage of the total number of genera in the tribe to which it belongs (after Bremer 1994).

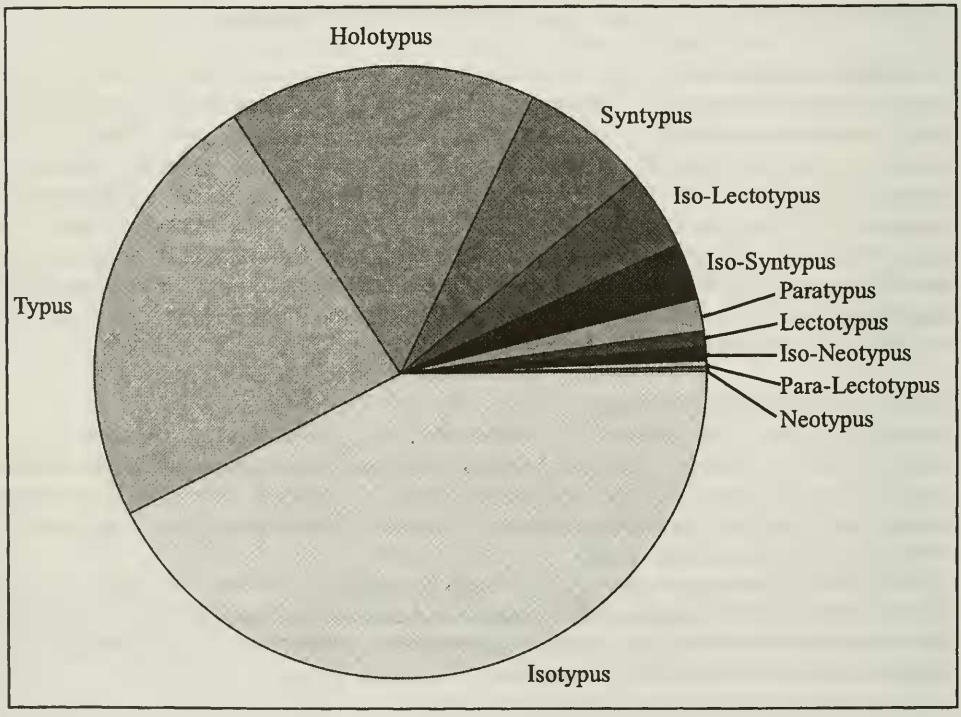


Diagram 2: Percentile distribution of type categories over a sample of 1,600 Compositae types held in Munich.

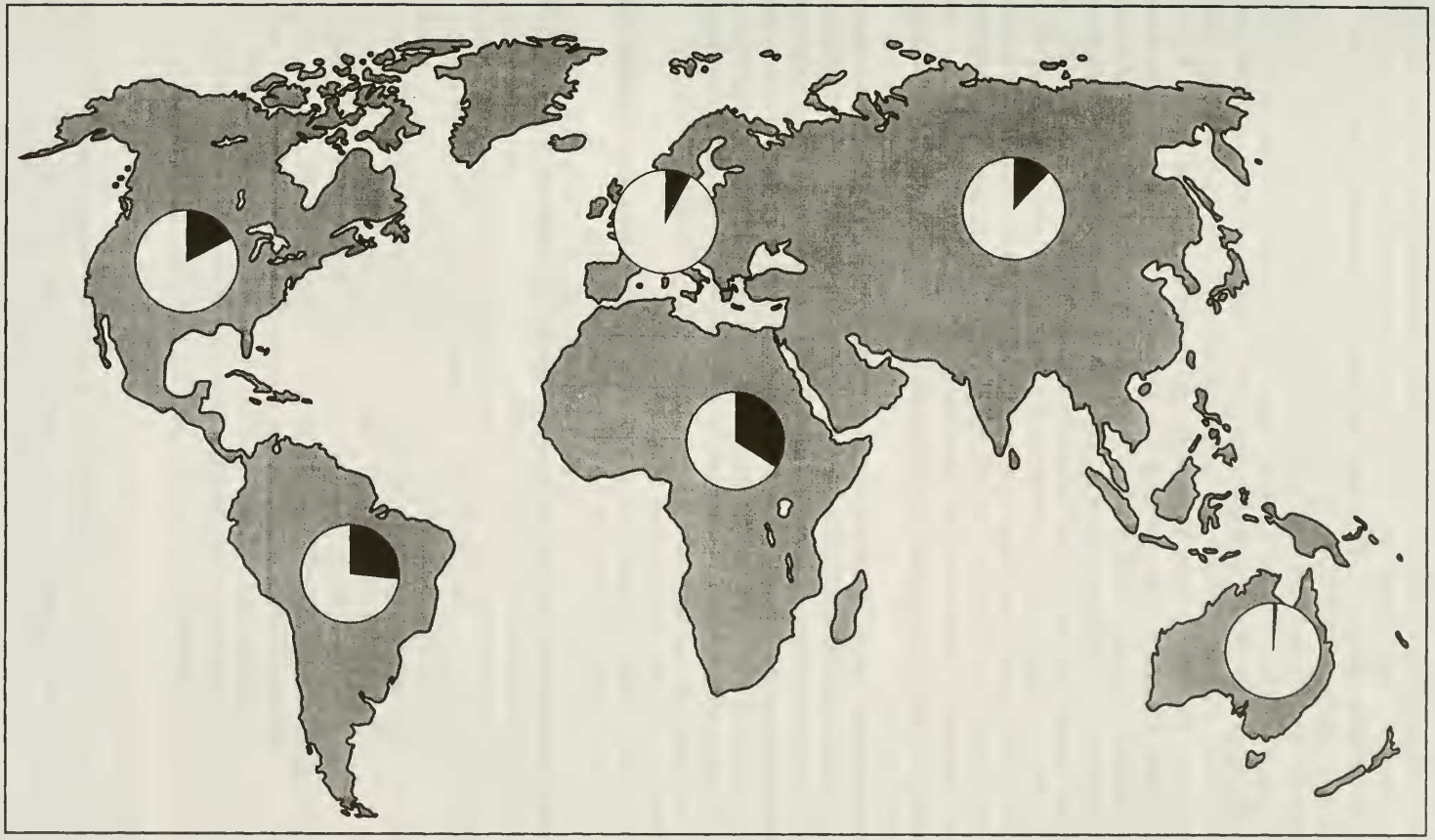


Diagram 3: The continental distribution of a sample of 1,600 nomenclatural types held in Munich (M + MSB). Each circle (100 %) represents the Compositae type collection in Munich, and the black section indicates the proportion of types provenanced from the continent on which it is placed.

Other important New World collections deposited in M and MSB were made by Miguel Bang (1853–1936) and Cyrus Guernsey Pringle (1838–1911). Between 1889 and 1894 the Danish-born botanist Bang brought sets of herbarium specimens from Bolivia to Europe (STAFLEU & MENNEGA 1992–2000). They were distributed to numerous herbaria all over the world, as were the duplicates of Pringle's "Plantae Mexicanae" (collected 1880–1909).

The names of the German botanists Christian Friedrich Ecklon (1795–1868) and Georg Wilhelm Schimper (1804–1878) repeatedly occur on the herbarium labels in Munich. Both earned their living by collecting plants for the renowned "Botanischer Reiseverein Esslingen", also called "Unio itineraria". Ecklon was a professional plant-collector in South Africa, working mainly on the Cape of Good Hope. From 1837 onwards, Schimper, by far the most important collector for this society, explored the flora of Northeast Africa. He married a daughter of the king of Tigre, settled down in "Abyssinia", nowadays Ethiopia, and became governor of the district of Antitscho, where he died in 1878. The Compositae in his enormous collection were mainly revised by Carl Heinrich Schultz "Bipontinus" (1805–1867), the specialist for this plant family of his era (STAFLEU & COWAN 1976–1988). Another significant author of new descriptions in the Compositae was the Swiss botanist Augustin Pyramus de Candolle (1778–1841), who edited the "Prodromus systematis naturalis regni vegetabilis", a fundamental taxonomic treatment of the Dicotyledoneae. He completed the first seven volumes of this magnum opus himself. On his death his son, Alphonse, carried on to volume 17 (MÄGDEFRAU 1992).

Further examples of private herbaria found among the Munich material include those of Franz von Paula von Schrank (1747–1835), Johann Christian Daniel von Schreber (1739–1810), and Joseph Gerhard Zuccarini (1797–1848). Schrank was the first director of the "Herbarium Regnum Monacense", founded with the material from the private collection of Schreber, which was purchased for this purpose in 1813. Zuccarini succeeded Schrank as Curator in Munich on his death in 1835, where he remained until 1848, nearly doubling the size of the herbarium during his tenure. He was an energetic collector of plants and other botanists collections (HERTEL & SCHREIBER 1988).

The names given in table 1 represent the most prolific botanists whose type material is held in Munich. These are distributed over both the 19th and 20th centuries.

Table 1: Authors and collectors (arranged alphabetically) significantly represented among the Munich Compositae types (based on a sample of ca 1,000 types).

Contributors	19th Century	20th Century
Authors	J.G. Baker, A.P. de Candolle, J.M. Greenman, K.A.O. Hoffmann, F.W. Klatt, B.L. Robinson, H.H. Rusby, F. von P. von Schrank, C.H. Schultz "Bipontinus", S. Watson	F.H. Hellwig, O.M. Hilliard (& B.L. Burtt), H. Merxmüller, R.B. Nordenstam, D. Podlech, K.H. Rechinger
Collectors	M. Bang, W.J. Burchell, C.F. Ecklon, J.M. Hildebrandt, C.G.T. Kotschy, C.F.P. von Martius, C.G. Pringle, G.W. Schimper	O. Degener et al., O.M. Hilliard (& B.L. Burtt), R.B. Nordenstam, D. Podlech, K.H. Rechinger

Concluding Remarks

For historical reasons, many types originating from developing countries have attained value through European botanical research, and are held in European herbaria. INFOCOMP is a project that uses modern archiving techniques to make these traditional botanical resources globally available, also in the countries of origin. The advantages of digitisation as a method of recording and distributing archival material are many, and benefit both the holding

institution and the user. It is an important step for herbaria to be able to provide the type specimens to scientists worldwide, especially those whose resources may be limited, while safeguarding the material itself.

It is anticipated that the work in Munich, including the presentation of the information for INTERNET access, will be completed by the end of 2002. The URL has not yet been finalised, but any updates on availability may be found on the introductory web page www.BotanischeStaatssammlung.de under "projects". INFOCOMP is unique because it offers the synantherologist a series of images of the nomenclatural type material accompanied by carefully evaluated bibliographic information.

The type collections of the Compositae are extensive, and mostly reliably identified within the herbarium in Munich. It is reasonable to assume that type collections from other families held in Munich are equally well represented. However, there are no definite plans at this moment to continue the digital archiving of further collections held in Munich beyond the end of this project.

Acknowledgements

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http://www.fmnh.org/research_collections/botany/collections_type_photo.htm (11 July 2002)
Swedish Museum of Natural History (S)
http://linnaeus.nrm.se/botany/fbo/welcome.html.en (11 July 2002)
Leiden Nationaal Herbarium (L)
http://nhncml.leidenuniv.nl/#types (11 July 2002)
National Herbarium of New South Wales (UNSW)
http://plantnet.rbgsyd.gov.au/HerbLink/NSWtypes/ (11 July 2002)
Missouri Botanical Gardens (MO)
http://www.mobot.org/ (under W3TROPICOS) (11 July 2002)
New York Botanical Gardens (NYBG)
Museum Berlin-Dahlem (B)
http://www.bgbm.fhttp://www.nybg.org/bsci/herbarium_imaging/ (11 July 2002)
Botanischer Garten und Botanisches u-berlin.de/biodivinf/projects/digitalisierung/default.htm (11 July 2002)

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